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THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Robert R. Rice, et al.
Serial No.	:	10/729,261
Filing Date	:	December 5, 2003
For	:	MULTIMODE RAMAN FIBER DEVICE WITH MODE DISCRIMINATION
Group Art Unit	:	2828
Examiner	:	Tod Thomas Van Roy
Attorney Docket No.	:	NG(ST)7621

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APPEAL BRIEF

Sir:

Pursuant to the Notice of Appeal filed in this case on November 20, 2007, Appellants present herewith their Brief on appeal.

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II. REAL PARTY IN INTEREST

The real party in interest is Northrop Grumman Corporation.

III. <u>RELATED APPEAL AND INTERFERENCES</u>

There are no related appeals, interferences, or judicial procedures under 37 C.F.R. §41.37(1)(c)(ii).

IV. STATUS OF CLAIMS

Claims 1-17, which are attached in Section X. Claims Appendix, beginning on page 33, are currently pending in this application. Claims 1-17 stand rejected. Specifically, claims 1-5, 12, and 13 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Publication No. 2002/0135866 to Sasaoka, et al. ("Sasaoka") in view of U.S. Patent No. 6,363,087 to Rice ("Rice"). Claims 6-9, 11, and 14-17 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Sasaoka and Rice in view of WO 02/50964 A2 to Clarkson ("Clarkson"). Claim 10 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Sasaoka, Rice and Clarkson, and further in view of U.S. Publication No. 2003/0161361 to Paldus, et al. ("Paldus").

Claims 1-17 are currently under appeal.

V. STATUS OF AMENDMENTS

A Final Office Action was mailed on August 21, 2007. No amendments have been entered since the submission of the Final Office Action dated August 21, 2007.

VI. SUMMARY OF THE CLAIMED SUBJECT MATTER

One aspect of the present invention, as recited in claim 1, provides a multimode optical fiber (FIG. 1, 10) that favors lower order modes (Paragraph 16). A core (FIG. 1, 12) can have a longitudinal optical axis and can incorporate radially dependent amounts of dopant materials to provide a desired refractive index profile (FIG. 2, 20) and a desired Raman gain coefficient profile (FIG. 2, 22) that favors lower order modes and discriminates against higher order modes (Paragraphs 15 and 16). A cladding region (FIG. 1, 14) can surround the core (FIG. 1, 12) and can have a refractive index different from that of the core material (Paragraph 16). Light launched into an end of the fiber (FIG. 1, 10) is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes (Paragraphs 16 and 24).

Another aspect of the invention, as recited in claim 2, provides that the core (FIG. 1, 12) incorporates radially dependent amounts of selected transparent oxides, to provide radially dependent control of the refractive index (FIG. 2, 20); and radially dependent amounts of a dopant that affects the Raman gain coefficient, to provide a radially dependent Raman gain coefficient profile (FIG. 2, 22). The refractive index and the Raman gain coefficient have their highest values along the optical axis of the fiber (FIG. 1, 10; Paragraph 15).

Another aspect of the invention, as recited in claim 4, provides that the refractive index profile (FIG. 2, 20) and the Raman gain coefficient profile (FIG. 2, 22) both have a generally parabolic shape with a peak coinciding with the optical axis of the fiber (FIG. 1, 10; Paragraph 15).

Another aspect of the invention, as recited in claim 5, provides that dopant concentrations are selected to provide a measure of independent control over the refractive index profile (FIG. 2, 20) and the Raman gain coefficient profile (FIG. 2, 22; Paragraph 16).

Another aspect of the invention, as recited in claim 6, provides a Raman laser oscillator (FIG. 3). A multimode optical fiber (FIG. 1, 10) favors lower order modes (Paragraph 16). The fiber (FIG. 1, 10) comprises a core (FIG. 1, 12) having a longitudinal optical axis and incorporating radially dependent amounts of dopant materials to provide a desired refractive index profile (FIG. 2, 20) and a desired Raman gain coefficient profile (FIG. 2, 22) that favors lower order modes and discriminates against higher order modes (Paragraphs 15 and 16). A cladding region (FIG. 1, 14) surrounds the core (FIG. 1, 12) and has a refractive index different from that of the core material (Paragraph 16). A diode laser array (FIG. 3, 34) provides pump power to the laser oscillator (FIG. 3; Paragraph 24). Means for launching (FIG. 3, 36; FIG. 4, 46) launch the pump power into the fiber (FIG. 1, 10; Paragraphs 24 and 26). Reflective means (FIG. 3, 30, 32; FIG. 4, 40) define a laser cavity encompassing the fiber (FIG. 1, 10; Paragraph 24). Light launched into an end of the fiber (FIG. 1, 10) is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes (Paragraphs 16 and 24).

Another aspect of the invention, as recited in claim 7, provides that the refractive index profile (FIG. 2, 20) and the Raman gain coefficient profile (FIG. 2, 22) both have a generally parabolic shape with a peak coinciding with the optical axis of the fiber (FIG. 1, 10; Paragraph 15).

Another aspect of the invention, as recited in claim 9, provides that the reflective means (FIG. 3, 30, 32; FIG. 4, 40) comprises a highly reflective mirror (FIG. 3, 32) at one end of the fiber (FIG. 1, 10) and a partially transmitting mirror (FIG. 3, 30; FIG. 4, 40; Paragraph 24). The oscillator (FIG. 3) further comprises optical means (FIG. 3, 36; FIG. 4, 46) for receiving light emitted from the other end of the fiber (FIG. 1, 10) and transmitting a generally collimated beam to the partially transmitting mirror (FIG. 3, 30; FIG. 4, 40; Paragraph 24).

Another aspect of the invention, as recited in claim 11, provides a method of generating a diffraction limited high brightness laser beam in a multimode fiber (FIG. 1, 10). A multimode fiber (FIG. 1, 10) is provided having a core (FIG. 1, 12) with radially dependent amounts of at least one dopant that provides a refractive index profile (FIG. 2, 20) and a Raman gain index profile (FIG. 2, 22) with maxima coinciding with an optical axis of the fiber (FIG. 1, 10; Paragraphs 15 and 16). High brightness pump power is generated in a laser diode array (FIG. 3, 34; Paragraph 24). The pump power is launched into one end of the multimode fiber (FIG. 1, 10; Paragraph 24). The fiber (FIG. 1, 10) favors the lowest order mode by providing maximum Raman gain along the optical axis, and discriminates against higher order modes (FIG. 3, 34; Paragraph 16). A laser cavity is provided that encompasses the multimode fiber (FIG. 1, 10; Paragraph 24). A diffraction limited high brightness beam (FIG. 3, 38) is output from the laser cavity (Paragraph 24).

Another aspect of the invention, as recited in claim 12, provides that the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an

interface between the core (FIG. 1, 12) and the cladding region (FIG. 1, 14) with a gradual transition to a maximum amount at the optical axis (Paragraph 16).

Another aspect of the invention, as recited in claim 14, provides that the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between the core (FIG. 1, 12) and the cladding region (FIG. 1, 14) with a gradual transition to a maximum amount at the optical axis (Paragraph 16).

Another aspect of the invention, as recited in claim 17, provides incorporating a minimum amount of dopant material near an interface between the core (FIG. 1, 12) and the cladding region (FIG. 1, 14) with a gradual transition to a maximum amount at the optical axis (Paragraph 16).

VII. GROUNDS FOR REJECTION TO BE REVIEWED ON APPEAL

1. Whether claims 1-5, 12, and 13 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Publication No. 2002/0135866 to Sasaoka, et al. ("Sasaoka") in view of U.S. Patent No. 6,363,087 to Rice ("Rice").

2. Whether claims 6-9, 11, and 14-17 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Sasaoka and Rice in view of WO 02/50964 A2 to Clarkson ("Clarkson").

3. Whether claim 10 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Sasaoka, Rice and Clarkson, and further in view of U.S. Publication No. 2003/0161361 to Paldus, et al. ("Paldus").

VIII. ARGUMENTS FOR CLAIMS 1-17

1. 35 U.S.C. §103(a) rejection of claims 1-5, 12, and 13 as being unpatentable over Sasaoka in view of Rice.

In making a determination of obviousness under 35 U.S.C. §103(a), the scope and contents of the prior art are determined; the differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1734 (2007); citing *Graham v. John Deere*, 383 U.S. 1, 17-18, 86 S. Ct. 684, 15 L. Ed. 2d 545 (1966).

i. The combination of Sasaoka and Rice does not teach or suggest the recitations of claim 1.

Claim 1 is patentable over Sasaoka in view of Rice because neither Sasaoka nor Rice, individually or in combination, teaches or suggests incorporating radially dependent amounts of dopant materials to provide a desired Raman gain coefficient profile that favors lower order modes and discriminates against higher order modes, and that light launched into an end of the fiber is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes, as recited in claim 1.

In the Final Office Action dated August 21, 2007 (hereinafter "Final Office Action"), the Examiner asserts that Sasaoka discloses that light launched into an end of the fiber is subject to

higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes, as recited in claim 1, based on what the Examiner alleges to be a doping profile, as disclosed in Sasaoka (Final Office Action, page 5; citing Sasaoka, paragraph 22; FIG. 1B). Representative for Appellant respectfully disagrees. Sasaoka discloses a fiber having a Raman gain coefficient of G_R/A_{eff} of 0.005 $(W*m)^{-1}$ (Sasaoka, paragraph 26). Therefore, the Raman gain coefficient that is disclosed in Sasaoka is a value that is dependent only on effective area for a given wavelength of light (Sasaoka, paragraph 26). Accordingly, Representative for Appellant respectfully submits that the disclosure of a Raman gain coefficient of G_R/A_{eff} of 0.005 $(W*m)^{-1}$ by Sasaoka is insufficient to demonstrate a teaching or suggestion of light that is launched into an end of the fiber being subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes, as recited in claim 1.

In the Final Office Action, as well as the Advisory Action dated November 15, 2007 (hereinafter, "Advisory Action"), the Examiner "agrees that Sasaoka discloses a Raman gain coefficient as a function of wavelength and area of G_R/A_{eff} of 0.005 $(W*m)^{-1}$," (Final Office Action, page 2; Advisory Action, page 2). The Examiner proceeds to state that "this is only a minimum value," and that "it does not mean that the value is uniform across the diameter of the fiber," (Final Office Action, page 2). Representative for Appellant respectfully submits that there is no teaching or suggestion in Sasaoka to support the Examiner's assertion. Specifically, there is no teaching or suggestion in Sasaoka that the Raman gain coefficient has higher values along the optical axis of the fiber.

To establish a prima facie case of obviousness, all of the claimed limitations must be taught or suggested by the prior art reference(s) (MPEP §2142; see, *e.g.*, *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Representative for Appellant respectfully submits that, absent a teaching or suggestion in Sasaoka to the contrary, it is insufficient for the Examiner to draw the conclusion that the minimum value of the Raman gain coefficient taught by Sasaoka does not mean that the value is uniform across the diameter of the fiber. In other words, without a teaching or suggestion in Sasaoka that the Raman gain coefficient has higher values along the optical axis of the fiber, it is improper for the Examiner to assume that Sasaoka teaches that the Raman gain coefficient has higher values along the optical axis of the fiber based on the stated Raman gain coefficient being a minimum value.

Furthermore, as described above and conceded by the Examiner, the Raman gain coefficient disclosed by Sasaoka is a function of wavelength for a given area (Sasaoka, paragraph 26; see Final Office Action, page 2). Since the Raman gain coefficient is a static value for "a given area", as conceded by the Examiner, the Examiner's conclusion that it does not mean that the value is uniform across the diameter of the fiber is logically inconsistent. Specifically, the "given area" could encompass the optical axis, the entire core of the fiber, or a section of the fiber that does not include the optical axis. However, Sasoaka specifically teaches that the value of the Raman gain coefficient varies only as a function of the amount of area, and not as a function of a specific location of the area in the cross-section of the fiber. That the disclosed Raman gain coefficient is a minimum value, as disclosed in Sasaoka and relied upon by the Examiner in rejecting claim 1, is irrelevant to a determination of a higher Raman gain

along the optical axis, as higher values of the Raman gain coefficient would still be described as a function of area as opposed to a location of the effective area in the fiber. There is no teaching or suggestion in Sasaoka that the "given area" in determining the Raman gain coefficient is specific to a particular portion of the fiber, or that particular portions of the fiber contribute differently to the Raman gain coefficient for the static value based on area. If Sasaoka did teach that the Raman gain coefficient was greater at the optical axis, the provided Raman gain coefficient would not just be dependent on a given area, but would be described as radially dependent (*e.g.*, via an integral with defined bounds from optical axis to core-edge). However, since Sasaoka fails to define the Raman gain coefficient in such a manner, the Raman gain coefficient taught by Sasaoka must be uniform across the diameter of the fiber.

Representative for Appellant also respectfully submits that the same equation is presented in the disclosure of Rice, though with regard to the Raman gain of the system including the fiber instead of the Raman gain of the fiber alone. Specifically, Rice discloses a Raman gain of the system expressed by $(g_R*P_p)/A_p$, where g_R is the Raman gain coefficient, P_p is the pump beam power, and A_p is the cross-sectional area of the pump core (Rice, col. 3, ll. 46-48). In describing this equation, Rice discloses that this Raman gain is *uniformly distributed* at every point over the Raman pump core (Rice, col. 3, ll. 43-46; emphasis added). As the difference between the equation for Raman gain described in Rice for the system and the Raman gain described in Sasaoka for the fiber is only a product of the pump power, as described in Rice, it is demonstrated that the Raman gain is expressed the same for the optical fiber in both references, and that such expression for Raman gain of the optical fibers is uniformly distributed. Therefore,

Sasaoka does not teach or suggest that light launched into an end of the fiber is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes, as recited in claim 1.

In addition, in the Advisory Action, the Examiner states the following:

> [F]igure 1b [of Sasaoka] is relied upon to further show the refractive index changes made via the GeO2 doping. This index profile is consistent with radial doping and provides additional evidence to the presence of the claimed Raman gain profile. Both the teaching of the value and the profile found in figure 1b work to demonstrate the necessary occurrence of the Raman gain profile. (Advisory Action, page 2).

Representative for Appellant respectfully disagrees with these statements. FIG. 1B of Sasaoka demonstrates a refractive index profile of an optical fiber (Sasaoka, FIG. 1B; paragraph 23). Sasaoka also discloses that "[t]he core region is doped with GeO_2 in order to attain a refractive index higher than that of pure silica, whereas the first cladding region is doped with F element in order to attain a refractive index lower than that of pure silica," (Sasaoka, paragraph 22). Accordingly, Representative for Appellant respectfully submits that it is inappropriate for the Examiner to state that FIG. 1B demonstrates "changes" to a refractive index profile, and that the refractive index profile is consistent with radial doping. In making these assertions, the Examiner provides no supportive basis from the disclosure of Sasaoka or otherwise. Specifically, there is no indication in the disclosure of Sasaoka that the doping of the fiber of Sasaoka with GeO_2 effects a "change" in the refractive index profile, as suggested by the Examiner. There is also no indication in the disclosure of Sasaoka that the refractive index profile demonstrated in FIG. 1B of Sasaoka results from radial doping. Instead, Sasaoka merely

discloses that the optical fiber is doped with GeO_2. Representative for Appellant thus respectfully submits that Sasaoka does not teach or suggest incorporating radially dependent amounts of dopant materials to provide a desired Raman gain coefficient profile that favors lower order modes and discriminates against higher order modes, or that a Raman gain coefficient profile has a highest value at the optical axis.

With regard to the refractive index profile described by FIG. 1B of Sasaoka, the Examiner further states the following:

> The Examiner agrees that Sasaoka teaches the dopant profile (fig. 1b) to be radially dependent and to be used to affect the refractive index. However, due to Sasaoka's use of GeO2, the dopant profile would also inherently adjust the Raman gain profile. The doping profile taught in fig. 1b is radially dependent, and shows increased refractive index at the center point of the fiber. This indicates heavier doping at the center with radially decreasing amounts away from the center. The Raman profile would inherently follow this pattern as well. (Advisory Action, page 3).

The Examiner also states the Present Application describes doping using GeO_2 in the same basic pattern of Sasaoka, resulting in the Raman gain profile (Final Office Action, page 4; citing Present Application, paragraphs 6 and 16; FIG. 2). Representative for Appellant further respectfully disagrees with these statements, and respectfully submits that the Examiner has mischaracterized the teachings of Sasaoka. As described above, Sasaoka does not teach or suggest radially dependent doping. Instead, FIG. 1B of Sasaoka demonstrates a refractive index profile, and not a dopant profile as asserted by the Examiner. At no point has Representative for Appellant provided any link between the refractive index profile of FIG. 1B and radially dependent doping, such that it is inappropriate for the Examiner to "agree" that Sasaoka teaches a

dopant profile based on the refractive index profile of FIG. 1B. Representative for Appellant also respectfully submits that it is inappropriate for the Examiner to state that it is inherent for the Raman gain profile to follow the pattern described by FIG. 1B, as such a statement is based on an incorrect interpretation of the teachings of Sasaoka. Specifically, there is no teaching or suggestion in Sasaoka or otherwise that a Raman gain profile is related to, and therefore would inherently follow, a refractive index profile. As such, the Examiner's statement that the Raman gain profile of the fiber of Sasaoka must inherently follow the pattern described by FIG. 1B of Sasaoka is improper. Furthermore, Representative for Applicant respectfully submits that the Present Application does not describe doping using GeO_2 in the same basic pattern of Sasaoka, resulting in the Raman gain profile, as asserted by the Examiner. Specifically, contrary to the Examiner's assertion, the "basic pattern" described in Sasaoka is with reference to a refractive index profile, not a doping profile, and Sasaoka discloses only that the fiber is doped with GeO_2, and not radially dependently doped, as recited in claim 1.

In the Advisory Action, the Examiner agrees that Sasaoka teaches a single mode fiber, but asserts that Sasaoka "motivates the use of a multimode fiber by incorporating Rice," and that "Sasaoka's doping, plus Rice's multimode fiber, gives the mode discrimination function," (Advisory Action, page 2). As described above, Sasaoka teaches a single mode fiber, such that the fiber does not favor lower order modes and discriminate against higher order modes based on the transmission of only a single mode. In addition, Rice discloses an optical fiber that includes a single mode core, as well as a Raman pump core and a cladding that together form a dual cladding (Rice, col. 2, line 63 through col. 3, line 4). In the system of Rice, a high power

multimode laser beam is pumped into the Raman pump core and is converted into a single mode beam at a Raman shifted wavelength in the single mode core (Rice, col. 2, ll. 53-55; col. 3, ll. 31-34 and 48-50). Representative for Appellant thus respectfully submits that there is no motivation for one of ordinary skill in the art to combine the teachings of Rice with the teachings of Sasaoka to achieve a multimode fiber that favors lower order modes and discriminates against higher order modes, as recited in claim 1.

The refractive index profile of Sasaoka is taught by Sasaoka to affect chromatic dispersion, such that Raman amplification can occur more efficiently with less nonlinear optical phenomena deterioration (Sasaoka, paragraphs 26 and 27). The refractive index profile of Sasaoka does not, however, affect the favoring of lower order modes and the discrimination against higher order modes, as described above regarding the transmission of a single mode. Rice, on the other hand, discloses that multimode optical signals are converted into a single mode signal. As a result, the fiber disclosed in Rice already favors lower order modes and discriminates against higher order modes. Representative for Appellant is thus left to wonder why one of ordinary skill in the art would implement a refractive index profile of a single mode fiber, as taught by Sasaoka, into a multimode fiber, as taught by Rice, to achieve a multimode fiber that favors lower order modes and discriminates against higher order modes when the fiber that is disclosed in Rice already achieves such favoring of lower order modes and discrimination against higher order modes.

In the Final Office Action, the Examiner asserts that one of ordinary skill in the art would be motivated to combine the fiber of Sasaoka with the core and cladding sizing of Rice to allow

for increased amplification of the lowest order mode while enabling efficient pumping via multimode pump sources (Final Office Action, pages 5-6; citing Rice col. 4, ll. 32-36). Representative for Appellant respectfully submits that the asserted motivation is improper in view of the respective disclosures of both Sasaoka and Rice. Specifically, as described above, the fiber of Rice includes a single mode core, as well as a Raman pump core and a cladding that together form a dual cladding (Rice, col. 2, line 63 through col. 3, line 4). Therefore, Rice already includes a single mode core, such that it is not apparent what, if any, effect could be achieved by incorporating the Raman pump core taught by Rice into the optical fiber of Sasaoka, as suggested by the Examiner. Specifically, as described above, the system of Rice already achieves the effect that the Examiner purports with regard to the motivation for combination. The cited section of Rice states that "increased amplification of the lowest order mode while enabling efficient pumping via multimode pump sources" is the "principal advantage" of the optical fiber of Rice (Rice, col. 4, ll. 32-35). Therefore, the Examiner has not provided an adequate reason for one of ordinary skill in the art to combine the teachings of Rice and Sasaoka, nor does the disclosure of Rice and/or Sasaoka provide any teaching or suggestion for such a combination. Accordingly, the motivation for the combination of Sasaoka and Rice as asserted by the Examiner is insufficient, as the Examiner has failed to provide some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness, such that there is no reason that would have prompted a person of ordinary skill in the relevant field to combine the disclosures of the Rice and/or Sasaoka to achieve in a manner to achieve the combination of elements of claim 1. See *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1741 (2007), *citing In re*

Kahn, 441 F.3d 977, 988 (CA Fed. 2006). As a result, Representative for Appellant respectfully submits that such a conclusion of the motivation to combine the fibers of Sasaoka and Rice, as asserted by the Examiner in the Final Office Action, must be a result of impermissible hindsight, such that the motivation takes into account knowledge gleaned only from applicant's disclosure." *In re McLaughlin* 443 F.2d 1392, 1395, 170 USPQ 209, 212 (CCPA 1971).

For all of the reasons stated above, it is respectfully submitted that neither Sasaoka nor Rice, individually or in combination, make obvious claim 1. Accordingly, withdrawal of this rejection is respectfully requested.

ii. <u>The combination of Sasaoka and Rice does not teach or suggest the recitations of claim 2-5.</u>

Claims 2-5 depend from claim 1, and are patentable over Sasaoka in view of Rice because neither Sasaoka nor Rice, individually or in combination, teaches or suggests claim 1, from which claims 2-5 depend. For all of the reasons stated above, it is respectfully submitted that neither Sasaoka nor Rice, individually or in combination, make obvious claims 2-5. Accordingly, withdrawal of the rejection of claims 2-5 is respectfully requested.

Furthermore, claim 2 further distinguishes the structure of claim 1 by reciting that the core comprises radially dependent amounts of a dopant that affects the Raman gain coefficient to provide a radially dependent Raman gain coefficient profile, and claim 4 further distinguishes the structure of claim 1 by reciting that the Raman gain coefficient profile has a generally parabolic shape. As described above regarding claim 1, Sasaoka, relied upon by the Examiner in rejecting claims 2 and 4 (Final Office Action, page 6), discloses a uniform Raman gain across the core of

the fiber (paragraph 26). Therefore, neither Rice nor Sasaoka, individually or in combination, teaches or suggests radially dependent amounts of a dopant that affects the Raman gain coefficient to provide a radially dependent Raman gain coefficient profile, as recited in claim 2, or that the Raman gain coefficient profile has a generally parabolic shape, as recited in claim 4. Accordingly, the combination of Rice and Sasaoka further does not make obvious claims 2 and 4.

iii. The combination of Sasaoka and Rice does not teach or suggest the recitations of claim 5.

Claim 5 depends from claim 1, and is patentable over Sasaoka in view of Rice because neither Sasaoka nor Rice, individually or in combination, teaches or suggests claim 1, from which claim 5 depends. In addition, claim 5 is patentable over Sasaoka in view of Rice because neither Sasaoka nor Rice, individually or in combination, teaches or suggests that dopant concentrations are selected to provide a measure of independent control over the refractive index profile and the Raman gain coefficient profile, as recited in claim 5.

In rejecting claim 2, from which claim 5 depends, the Examiner states that the disclosure of Sasaoka of doping using GeO_2 fulfills the requirement of claim 2 because claim 2 does not make clear that transparent oxides cannot perform both functions of affecting the refractive index profile and the Raman gain profile (Advisory Action, page 4). However, in rejecting claim 5, the Examiner asserts that Sasaoka teaches that the dopant concentrations are selected to provide a measure of control over the refractive index profile and the Raman gain coefficient profile based on the inherency of the doping of the Silicon fiber adjusting the refractive index and the Raman

gain profile (Final Office Action, page 6). Representative for Appellant respectfully submits that these two statements with regard to the rejections of claim 5 and claim 2, from which claim 5 depends, are inconsistent. Specifically, the Examiner concedes through admission that doping using GeO_2, as described in Sasaoka, performs both functions of affecting the refractive index profile and the Raman gain profile. However, by affecting both the refractive index profile and the Raman gain profile with a single dopant, the refractive index profile and the Raman gain profile cannot be *independently* controlled by selecting dopant concentrations, as recited in claim 5, because doping the fiber of Sasaoka with GeO_2 affects both profiles, as admitted by the Examiner. Accordingly, the combination of Rice and Sasaoka does not make obvious claim 5. Withdrawal of this rejection is therefore respectfully requested.

iv. The combination of Sasaoka and Rice does not teach or suggest the recitations of claim 12 and 13.

Claims 12 and 13 depend from claim 1, and are patentable over Sasaoka in view of Rice because neither Sasaoka nor Rice, individually or in combination, teaches or suggests claim 1, from which claims 12 and 13 depend. For all of the reasons stated above, it is respectfully submitted that neither Sasaoka nor Rice, individually or in combination, make obvious claims 12 and 13. Accordingly, withdrawal of the rejection of claims 12 and 13 is respectfully requested.

Furthermore, claim 12 further distinguishes the structure of claim 1 by reciting that the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between the core and the cladding region with a gradual transition to a maximum amount at the optical axis. As described above regarding claim 1, Sasaoka, relied

upon by the Examiner in rejecting claim 12 (Final Office Action, page 6), discloses only that the fiber is doped with GeO_2, but nowhere describes that the doping with GeO_2 is radially dependent. Therefore, neither Rice nor Sasaoka, individually or in combination, teaches or suggests that the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between the core and the cladding region with a gradual transition to a maximum amount at the optical axis, as recited in claim 12. Accordingly, the combination of Rice and Sasaoka further does not make obvious claim 12.

2. 35 U.S.C. §103(a) rejection of claims 6-9, 11, and 14-17 as being unpatentable over Sasaoka in view of Rice, and further in view of Clarkson.

In making a determination of obviousness under 35 U.S.C. §103(a), the scope and contents of the prior art are determined; the differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1734 (2007); citing *Graham v. John Deere*, 383 U.S. 1, 17-18, 86 S. Ct. 684, 15 L. Ed. 2d 545 (1966).

i. The combination of Sasaoka, Rice, and Clarkson does not teach or suggest the recitations of claim 6.

Claim 6 is patentable over Sasaoka in view of Rice, and further in view of Clarkson because Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest a multimode optical fiber that favors lower order modes, the fiber comprising a core having a longitudinal optical axis and incorporating radially dependent amounts of dopant materials to provide a desired refractive index profile and a desired Raman gain coefficient profile that favors lower order modes and discriminates against higher order modes, as recited in claim 6. In addition, claim 6 is patentable over Sasaoka, Rice, and Clarkson because Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest that light launched into an end of the fiber is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes, as also recited in claim 6.

As described above regarding claim 1, Sasaoka discloses a fiber having a Raman gain coefficient of G_R/A_{eff} of 0.005 $(W*m)^{-1}$ (Sasaoka, paragraph 26). Therefore, the Raman gain coefficient that is disclosed in Sasaoka is a value that is dependent only on effective area for a given wavelength of light (Sasaoka, paragraph 26). Sasaoka also discloses a refractive index profile of an optical fiber (Sasaoka, FIG. 1B; paragraph 23), and that that "[t]he core region is doped with GeO_2 in order to attain a refractive index higher than that of pure silica, whereas the first cladding region is doped with F element in order to attain a refractive index lower than that of pure silica," (Sasaoka, paragraph 22). Accordingly, for the reasons described above regarding claim 1, neither Rice nor Sasaoka teach or suggest incorporating radially dependent amounts of dopant materials to provide a desired refractive index profile and a desired Raman gain coefficient profile that favors lower order modes and discriminates against higher order modes,

such that light launched into an end of the fiber is subject to higher Raman gain along the optical axis, as recited in claim 6. Furthermore, also for the reasons stated above regarding claim 1, Representative for Appellant respectfully submits that there is no motivation for one of ordinary skill in the art to combine the teachings of Rice with the teachings of Sasaoka to achieve the combination of elements of claim 6, as asserted by the Examiner (see Final Office Action, pages 5-6 and page 7). In rejecting claim 6, the Examiner relies on Clarkson to teach a diode laser array providing pump power to the laser oscillator, means for launching the pump power into the fiber, and reflective means defining a laser cavity encompassing the fiber (Final Office Action, page 7). However, the addition of Clarkson does not cure the deficiencies of Rice and/or Sasaoka to teach or suggest the elements of claim 6. Accordingly, Sasaoka, Rice, and Clarkson, individually or in combination, do not make obvious claim 6. Withdrawal of this rejection is respectfully requested.

ii. The combination of Sasaoka, Rice, and Clarkson does not teach or suggest the recitations of claims 7-9.

Claims 7-9 depend from claim 6, and are patentable over Sasaoka in view of Rice and further in view of Clarkson because Sasaoka, Rice, and Clarkson, individually or in combination, does not teach or suggest claim 6, from which claims 7-9 depend. Furthermore, for the reasons stated above regarding claim 4, Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest claim 7. For all of the reasons stated above, it is respectfully submitted that Sasaoka, Rice, and Clarkson, individually or in combination, do not make obvious claims 7-9.

iii. <u>The combination of Sasaoka, Rice, and Clarkson does not teach or suggest the recitations of claims 11.</u>

Claim 11 is patentable over Sasaoka in view of Rice, and further in view of Clarkson because Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest providing a multimode fiber having a core with radially dependent amounts of at least one dopant that provides a refractive index profile and a Raman gain index profile with maxima coinciding with an optical axis of the fiber, as recited in claim 11. In addition, claim 11 is patentable over Sasaoka, Rice, and Clarkson because Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest favoring the lowest order mode by providing maximum Raman gain along the optical axis, and discriminating against higher order modes, as also recited in claim 11.

As described above regarding claim 1, Sasaoka discloses a fiber having a Raman gain coefficient of G_R/A_{eff} of 0.005 $(W*m)^{-1}$ (Sasaoka, paragraph 26). Therefore, the Raman gain coefficient that is disclosed in Sasaoka is a value that is dependent only on effective area for a given wavelength of light (Sasaoka, paragraph 26). Sasaoka also discloses a refractive index profile of an optical fiber (Sasaoka, FIG. 1B; paragraph 23), and that that "[t]he core region is doped with GeO_2 in order to attain a refractive index higher than that of pure silica, whereas the first cladding region is doped with F element in order to attain a refractive index lower than that of pure silica," (Sasaoka, paragraph 22). Accordingly, for the reasons described above regarding claim 1, neither Rice nor Sasaoka teach or suggest providing a multimode fiber having a core with radially dependent amounts of at least one dopant that provides a refractive index profile and a Raman gain index profile with maxima coinciding with an optical axis of the fiber, as

recited in claim 11. Furthermore, also for the reasons stated above regarding claim 1, Representative for Appellant respectfully submits that there is no motivation for one of ordinary skill in the art to combine the teachings of Rice with the teachings of Sasaoka to achieve the combination of elements of claim 11, as asserted by the Examiner (see Final Office Action, pages 5-6 and page 7). Similar to claim 6, the Examiner relies on Clarkson to teach generating high brightness pump power in a laser diode array, launching the pump power into one end of the multimode fiber, providing a laser cavity that encompasses the multimode fiber, and outputting a diffraction limited high brightness beam from the laser cavity (Final Office Action, page 7). However, the addition of Clarkson does not cure the deficiencies of Rice and/or Sasaoka to teach or suggest the elements of claim 11. Accordingly, Sasaoka, Rice, and Clarkson, individually or in combination, do not make obvious claim 11. Withdrawal of this rejection is respectfully requested.

iv. <u>The combination of Sasaoka, Rice, and Clarkson does not teach or suggest the recitations of claim 14 and 15.</u>

Claims 14 and 15 depend from claim 6, and are patentable over Sasaoka in view of Rice, and further in view of Clarkson, because Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest claim 6, from which claims 14 and 15 depend. For all of the reasons stated above, it is respectfully submitted that Sasaoka, Rice, and Clarkson, individually or in combination, do not make obvious claims 14 and 15. Accordingly, withdrawal of the rejection of claims 14 and 15 is respectfully requested.

Furthermore, claim 14 further distinguishes the structure of claim 6 by reciting that the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between the core and the cladding region with a gradual transition to a maximum amount at the optical axis. As described above regarding claim 6, Sasaoka, relied upon by the Examiner in rejecting claim 14 (Final Office Action, page 8), discloses only that the fiber is doped with GeO_2, but nowhere describes that the doping with GeO_2 is radially dependent. The addition of Clarkson does not cure the deficiencies of Sasaoka and/or Rice to teach or suggest this element of claim 14. Therefore, Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest that the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between the core and the cladding region with a gradual transition to a maximum amount at the optical axis, as recited in claim 14. Accordingly, the combination of Sasaoka, Rice, and Clarkson further does not make obvious claim 14.

v. <u>The combination of Sasaoka, Rice, and Clarkson does not teach or suggest the recitations of claim 16 and 17.</u>

Claims 16 and 17 depend from claim 11, and are patentable over Sasaoka in view of Rice, and further in view of Clarkson, because Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest claim 11, from which claims 16 and 17 depend. Furthermore, for the reasons stated above regarding claim 14, Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest claim 17. For all of the reasons stated above, it is respectfully submitted that Sasaoka, Rice, and Clarkson, individually or in

combination, do not make obvious claims 16 and 17. Accordingly, withdrawal of the rejection of claims 16 and 17 is respectfully requested.

3. 35 U.S.C. §103(a) rejection of claim 3 as being unpatentable over Sasaoka in view of Rice in view of Clarkson, and further in view of Paldus.

In making a determination of obviousness under 35 U.S.C. §103(a), the scope and contents of the prior art are determined; the differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1734 (2007); citing *Graham v. John Deere*, 383 U.S. 1, 17-18, 86 S. Ct. 684, 15 L. Ed. 2d 545 (1966).

i. The combination of Sasaoka, Rice, Clarkson, and Paldus does not teach or suggest the recitations of claim 10.

Claim 6, from which claim 10 depends, is patentable over Sasaoka in view of Rice and further in view of Clarkson because, for the reasons stated above regarding claim 6, Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest a multimode optical fiber that favors lower order modes, the fiber comprising a core having a longitudinal optical axis and incorporating radially dependent amounts of dopant materials to provide a desired refractive index profile and a desired Raman gain coefficient profile that favors lower order modes and

discriminates against higher order modes, as recited in claim 6, from which claim 10 depends. In addition, for the reasons stated above regarding claim 10, Sasaoka, Rice, and Clarkson, individually or in combination, do not teach or suggest that light launched into an end of the fiber is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes, as also recited in claim 6, from which claim 10 depends.

The Final Office Action states that the combination of Sasaoka, Rice, and Clarkson fails to disclose the use of a pinhole filter (Final Office Action, page 8). The Final Office Action relies on Paldus to teach a laser system using a pinhole filter (Final Office Action, page 8; citing Paldus, paragraph 71). However, Paldus does not cure the deficiencies of Sasaoka, Rice, and Clarkson to teach or suggest claim 6, from which claim 10 depends. Therefore, for all of the reasons stated above, it is respectfully submitted that Sasaoka, Rice, Clarkson, and Paldus, individually or in combination, do not make obvious claim 10.

IX. CONCLUSION AND SIGNATURE

Please charge any deficiency or credit any overpayment in the fees for this Appeal Brief to Deposit Account No. 20-0090.

Respectfully submitted,

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X. CLAIMS APPENDIX

1. A multimode optical fiber that favors lower order modes, the fiber comprising:

a core having a longitudinal optical axis and incorporating radially dependent amounts of dopant materials to provide a desired refractive index profile and a desired Raman gain coefficient profile that favors lower order modes and discriminates against higher order modes; and

a cladding region surrounding the core and having a refractive index different from that of the core material;

wherein light launched into an end of the fiber is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes.

2. A multimode optical fiber as defined in claim 1, wherein:

the core incorporates radially dependent amounts of selected transparent oxides, to provide radially dependent control of the refractive index; and radially dependent amounts of a dopant that affects the Raman gain coefficient, to provide a radially dependent Raman gain coefficient profile; and

the refractive index and the Raman gain coefficient have their highest values along the optical axis of the fiber.

3. A multimode optical fiber as defined in claim 2, wherein the dopant that affects the Raman gain coefficient is germanium oxide.

4. A multimode optical fiber as defined in claim 2, wherein the refractive index profile and the Raman gain coefficient profile both have a generally parabolic shape with a peak coinciding with the optical axis of the fiber.

5. A multimode optical fiber as defined in claim 2, wherein dopant concentrations are selected to provide a measure of independent control over the refractive index profile and the Raman gain coefficient profile.

6. A Raman laser oscillator, comprising:

a multimode optical fiber that favors lower order modes, the fiber comprising a core having a longitudinal optical axis and incorporating radially dependent amounts of dopant materials to provide a desired refractive index profile and a desired Raman gain coefficient profile that favors lower order modes and discriminates against higher order modes, and a cladding region surrounding the core and having a refractive index different from that of the core material;

a diode laser array providing pump power to the laser oscillator;

means for launching the pump power into the fiber; and

reflective means defining a laser cavity encompassing the fiber;

wherein light launched into the fiber is subject to higher Raman gain along the optical axis, which promotes lower order modes and discriminates against higher order modes.

7. A Raman laser oscillator as defined in claim 6, wherein the refractive index profile and the Raman gain coefficient profile both have a generally parabolic shape with a peak coinciding with the optical axis of the fiber.

8. A Raman laser oscillator as defined in claim 6, wherein the reflective means comprises a highly reflective mirror positioned at one end of the fiber and a partially transmitting mirror at the other end of the fiber.

9. A Raman laser oscillator as defined in claim 6, wherein:

the reflective means comprises a highly reflective mirror at one end of the fiber and a partially transmitting mirror; and

the oscillator further comprises optical means for receiving light emitted from the other end of the fiber and transmitting a generally collimated beam to the partially transmitting mirror.

10. A Raman laser oscillator as defined in claim 9, wherein the optical means comprises multiple lenses and a pinhole filter.

11. A method of generating a diffraction limited high brightness laser beam in a multimode fiber, the method comprising:

providing a multimode fiber having a core with radially dependent amounts of at least one dopant that provides a refractive index profile and a Raman gain index profile with maxima coinciding with an optical axis of the fiber;

generating high brightness pump power in a laser diode array;

launching the pump power into one end of the multimode fiber;

in the fiber, favoring the lowest order mode by providing maximum Raman gain along the optical axis, and discriminating against higher order modes;

providing a laser cavity that encompasses the multimode fiber; and

outputting a diffraction limited high brightness beam from the laser cavity.

12. A multimode optical fiber as defined in claim 1, wherein the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between the core and the cladding region with a gradual transition to a maximum amount at the optical axis.

13. A multimode optical fiber as defined in claim 1, wherein the fiber is configured to provide higher Raman gain along the optical axis for multimode light launched into the fiber.

14. A Raman laser oscillator as defined in claim 6, wherein the radially dependent amounts of dopant materials comprise a minimum amount of dopant material near an interface between

the core and the cladding region with a gradual transition to a maximum amount at the optical axis.

15. A Raman laser oscillator as defined in claim 6, wherein the fiber is configured to provide higher Raman gain along the optical axis for multimode light launched into the fiber.

16. The method of claim 11, wherein launching the pump power into one end of the multimode fiber comprises launching a multimode laser input into one end of the multimode fiber.

17. The method of claim 11, further comprising incorporating a minimum amount of dopant material near an interface between the core and a cladding region with a gradual transition to a maximum amount at the optical axis.

XI. EVIDENCE APPENDIX

There was no evidence relied upon in this brief that was submitted under 37 C.F.R. §§1.130-1.132, or otherwise submitted and entered into the record by the Examiner.

XII. RELATED PROCEEDINGS APPENDIX

There are no related appeals, interferences, or judicial procedures under 37 C.F.R. §41.37(1)(c)(ii).